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Applying Fuzzy Outranking Method to Measurement System of Multidimensional Performance

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Abstract

Performance measurement and evaluation are widely conducted in contemporary organizations. The decision-making ambiguity in performance measurement system research has been conceptually studied from accounting, organizational and behavioral perspectives, however it is still not paid major attention, although some fuzzy methodologies have been exploited in measuring and evaluating performance in several practical areas. The aim of this paper is to propose a general system of multidimensional performance evaluation and introduce performance rating into it by applying fuzzy outranking method. By doing this, the performances can be evaluated reciprocally through performance rating from multi-perspectives. Moreover, the system can be utilized for measuring and evaluating between divisions or companies.

Keywords: Multidimensional performance, Performance measurement systems, Balanced Scorecard, Fuzzy outranking

1. Introduction

Measuring and evaluating business and managerial performance of an organization is a multidimensional and considerably complicated task for managers since they have to balance the objectives of performances against each other and against not only today's but also tomorrow's competing demands[19]. Maximization of productivity and efficiency has been the major pursuit for the Taylorian organization in the industrial age, and the performance expression was financial usually with using the lagging measures such as standard cost ratios e.g. productivity ratios per month or the turnover per year. Financial and linear operators played the leading role in the performance measurement system for taking the appropriate action to improve productivity and increase efficiency. Afterward, performance measurement and evaluation become multicriteria, technical criteria was combined into financial criteria from such viewpoints as quality, delivery for pursuing effective cost-reduction through improving

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operational performance. As in the representative management methodologies at that time, there is no doubt that total quality control and value engineering can be recalled. Achievement of the necessary product function from the viewpoint of customer was added into the management control crossing multiple units: financial, procuring, engineering, marketing. Engineering, procuring and marketing are involved in the analysis process to define the priority requirements from customer's standpoint[4][16]. The target selling price, margins, and market share have been the leading measures. Nowadays, the view of "you can't manage without measuring, and what is measured gets done" is undeniable[8][9][10][15]. More and more sophisticated performance measurement systems for picturing more comprehensive portrait of organization related strategy objectives have been developed and exploited in practical area[18][14][13]. Meanwhile, the focus of the performance measurement and evaluation has shifted from cost-reduction to growth in recent years[3]. Among the be-used performance measurement systems, balanced scorecard (BSC) is the most popular one which is also the 6th of top 10 management tools in 2010[3]. In BSC, performance measures are grouped into four categories: financial, customer, internal process and learning and growth, and performance measurement and evaluation are balanced from the four perspectives (categories).

BSC consists mainly of the following processes[6][7][8][15]: recognizing organization architecture; defining strategy objective; selecting measures; and building implementation plan. Defining strategy objective and selecting measures are the core decision-making process in the system since strategy and vision of organization are understood, articulated and translated into a set of financial and non-financial measures and into a causal model with a step-by-step sequence of cause-and-effect relationships leading from the most fundamental aspects of performance to financial performance. The casual links between categories are hypothesized, that is, strong learning and growth leads to improved internal processes, improved internal processes lead to increased customer satisfaction, and increases in customer satisfaction leads to improved financial performance. Clearly, how to reflect the decision-makers' subjective understanding or insight rationally, and how to evaluate the relations among the measures effectively and efficiently should be essential and indispensable subject of measuring and evaluating performance[1][17][20], but they are often ignored somewhat for balancing the complexity and apperception, in other words, people in practice often keep away from evaluation of intangible substance such as human insight, beliefs, or understandings. The decision-making ambiguity in BSC mentioned above has being conceptually studied within accounting, organizational and behavioral perspectives, and has been dealt with by applying fuzzy methodologies in several practical areas[11][14][13][21]. However, it is still not paid major attention in performance measurement research. This paper aims to introduce performance rating into the multidimensional performance measurement system[5] by using fuzzy outranking method for performance evaluation.

The rest of the paper is organized as follows: first, the measurement and evaluation system of multidimensional performance is described in the following section, and the next section will propose a method for ranking the performance from multiple perspectives under the consideration for dealing with the decision-making ambiguity. An illustrative example shows how to use the method. Finally, a conclusion is discussed at the end.

2. The measurement and evaluation System of multidimentional performance

In this section, a BSC–based multidimensional performance measurement system[5] is described and shown in figure 1.

It starts from the initial stage, termed structural modeling, at which four perspective models (financial, customer, internal business process, and organization learning) are built up respectively through the processes encircled within the dotted line in the left side of figure 1. We also see it as multi-dimensional system analysis. In order to obtain a concrete model of the respective perspective, fuzzy structural modeling method[17] is applied to portray an intuitive graphical hierarchy with well-preserved

contextual relations among measurement elements. Firstly, evaluators' mental model (imagination) of the given problem are embedded and reflected on a structural model. Here, the measurement elements are specified by techniques such as nominal group techniques, questionnaire or interview according to the operational conditions. Then, the contextual relations among the elements are examined and represented based on the assumption of cause-and-effect. And the hierarchy of measurement system is constructed and drawn as an interpretive structural model. Furthermore, In order to compare the structural model with the mental model, a feedback for learning will be conducted by evaluators[22]. If an agreement among evaluators is obtained, then the process goes up to the next stage, and the result is set as the outcome of stage A. Otherwise, the modeling process restarts from the embedding process or from drawing out and representing the evaluating elements process. Then the process goes as same as illustrated in figure 1 until a consenting structural model is obtained.

As the outcome of stage A, the models of perspectives are obtained, which are evaluated respectively so as to obtain each evaluation value of each perspective model. Further, an integrated value is computed at stage C. At both of evaluating and integrating stage, multiple attributes decision making and/or fuzzy inference mechanism can be introduced for achieving the simultaneous optimization of multiple elements of system for determination of a satisfying solution to a given problem[23]. In addition, fuzzy outranking method is proposed to evaluate performance through performance rating at both stages in this paper in order to give the system a ranking function. Then if the evaluation value is valid, the process goes to the end, otherwise, a feedback will be conducted at stage D, back to the stage B or A, performed until a consenting integrated result is derived.

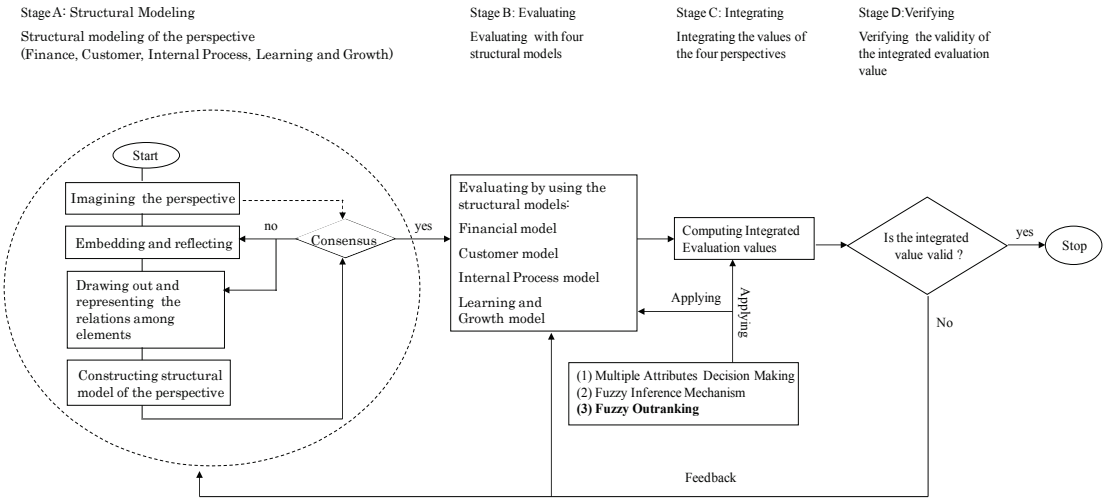

Figure 1 The BSC-based multidimensional performance measurement system

3. The fuzzy outranking method

The method to roughly compare two alternatives a and a' with loose relation, which means a is at least as good as a' or a is not worse than a', it says that a outranks a'. Reversely, If a' is evaluated better than a or they are incomparable to each other, it says that a dose not outrank a'. These relations are valued as 0 or 1 in the traditional outranking method[2], that is, a outranks a' implies $\mu(a, a') = 1$ and $\mu(a, a') = 0$ if a dose not outrank a'. In fuzzy outranking method[12], the outranking degree is valued between 0 and 1. More precisely, the degree is determined with a fuzzy membership function by using an indifference threshold q_i and a preference threshold p_i, where i represents one of evaluating criteria. Thus

the corresponding value is denoted by $c_i(a, a')\ i = 1, \dots, n$, and they are aggregated by a weighted average $\omega_1\ c_i(a, a') + \omega_2 c_2(a, a') + \cdots + \omega_n c_n(a, a')$with a set of weight $\{\omega_1, \omega_2, \dots, \omega_n\}$, and called concordance index denoted by $C(a, a')$. Another index is called discordance index denoted by $d_j(a, a')$, which is constructed by using a fuzzy set with the preference threshold p_i and a veto threshold v_i. This index represents the degree of discordance with the superiority of *a* over *a*'. Thus $d_j(a, a') = 1$ implies that the "*a* outranks *a*'" is exclusively vetoed from the number *j* point of view. If there are discordance points of view $j_1, \dots, j_k$, whose index are greater than $C(a, a')$, then the total outranking index $\mu(a, a')$ is calculated by the following formula,

$$\mu(a, a') = C(a, a') \times \frac{1 - d_{j_1}(a, a')}{1 - C(a, a')} \times \dots \times \frac{1 - d_{j_k}(a, a')}{1 - C(a, a')}.$$

According to the total outranking index $\mu(a, a')$, the performance rating is calculated by ELECTRE III[2]'s algorithm through building descending ranking and ascending ranking.

4. An illustrative example

Consider that there are four companies whose performance is evaluated from four perspectives: financial, customer, internal process, and learning and growth, denoted by $g_i\ i = 1,2,3,4$ respectively. With the limit of paper space, how to obtain the evaluation values of each perspective of each company from stage B of the system described in the second section are not shown in this section, only the evaluation values are shown in table 1

In this case, the weights of each perspective evaluation, the preference threshold, the indifference threshold, and the veto threshold are set as follows: wi={0.35, 0.30, 0.20, 0.15} (i=1,2,3,4), pi= 0.1 (i=1,2,3,4), qi= 0.05 (i=1,2,3,4), vi= 0.2, (i=1,2,3,4), and the calculation results are shown in the following tables respectively.

Table 1 The evaluation value of each company from the four perspectives

	g_1	g_2	g_3	g_4
a_1	0.526	0.638	0.736	0.549
a_2	0.724	0.534	0.512	0.493
a_3	0.637	0.739	0.436	0.443
a_4	0.423	0.495	0.675	0.598

Table 2 The corresponding value for each criterion

C_k	a_1'	a_2'	a_3'	a_4'
$C_1(a, a')$				
a_1	1	0	0	1
a_2	1	1	1	1
a_3	1	0.26	1	1
a_4	0	0	0	1
$C_2(a, a')$				

a_1	1	1	0	1
a_2	0	1	0	1
a_3	1	1	1	1
a_4	0	0	0	1
$C_3(a, a')$				
a_1	1	1	1	1
a_2	0	1	1	0
a_3	0	0.48	1	0
a_4	0.78	1	1	1
$C_4(a, a')$				
a_1	1	1	1	1
a_2	0.88	1	1	0
a_3	0	1	1	0
a_4	1	1	1	1

Table 3 The concordance index

$C(a, a')$	a'_1	a'_2	a'_3	a'_4
a_1	1	0.65	0.35	1
a_2	0.48	1	0.70	0.65
a_3	0.65	0.64	1	0.65
a_4	0.31	0.35	0.35	1

Table 4 The discordance indices

d_k	a'_1	a'_2	a'_3	a'_4
$d_1(a, a')$				
a_1	0	0.98	0.11	0
a_2	0	0	0	0.
a_3	0	0	0	0
a_4	0.03	1	1	0
$d_2(a, a')$				
a_1	0	0	0.01	0
a_2	0.04	0	1	0
a_3	0	0	0	0
a_4	0.43	0	1	0

$d_3(a, a')$				
a_1	0	0	0	0
a_2	1	0	0	0.63
a_3	1	0	0	1
a_4	0	0	0	0
$d_4(a, a')$				
a_1	0	0	0	0
a_2	0	0	0	0.05
a_3	0.06	0	0	1
a_4	0	0	0	0

Table 5 The total outranking index

$\mu(a, a')$	a_1'	a_2'	a_3'	a_4'
a_1	-	0.04	0.35	1
a_2	0	-	0	0.65
a_3	0	0.64	-	0
a_4	0.26	0	0	-

Table 6 Performance rating result

ranking	the result						
ascending	a_4	→	a_2	→	a_3	→	a_1
descending	a_1	←	a_3	←	a_2	←	a_4

5. Conclusive discussion

In today's business environment, performance measurement has been becoming more and more complicated, and its focus has shifted from cost-reduction to growth. This paper adopts the pragmatic standpoint, that is, despite the complexities and ambiguity in the decision-making regarding performance measurement systems, performance is measured and measurement and evaluation are widely used in contemporary organizations. In this paper, a system for measuring and evaluating multiple performances on basis of BSC was proposed, and further, introduced fuzzy outranking method into it for evaluating performances. A simple example was illustrated to show the validity of fuzzy outranking method in the proposed system. However how to use the proposed system with the other methods to simulate practical situation remain at this time, and it will be undertook in the future.

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